(12) UK Patent Application (19) GB (11) 2 125 950 A

(21) Application No 8316374
(22) Date of filing 16 Jun 1983
(30) Priority data
(31) 408104
(32) 16 Aug 1982
(33) United States of America (US)
(43) Application published 14 Mar 1984
(51) INT CL[3] F23R 3/08
(52) Domestic classification F4T 101 AK U1S 1987 F4T
(56) Documents cited
GBA 2061483
GB 1442350
GB 1344800
GB 0845971
GB 0763692
GB 0721209
(58) Field of search F4T

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(54) Gas turbine combustor

(57) Compressed air from a region surrounding a combustor of a gas turbine engine is utilized to accomplish at least two functions.
First, the compressed air flows through impingement cooling holes 62 in a combustor outer liner 60 to impingement cool combustor inner liner wall segments 64. This impingement air forms an impingement blanket 66 between the outer and inner liners. Second, the impingement air forming the impingement blanket is directed through dilution holes 68 to provide dilution air to the combustion process. Part of the impingement blanket air may also be utilized as film cooling air to film cool the inner liner.

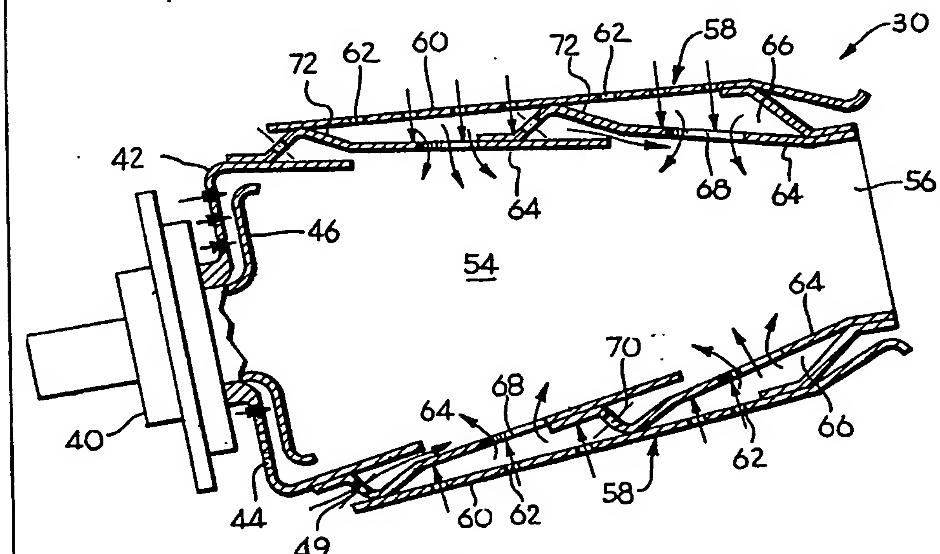

Fig 3

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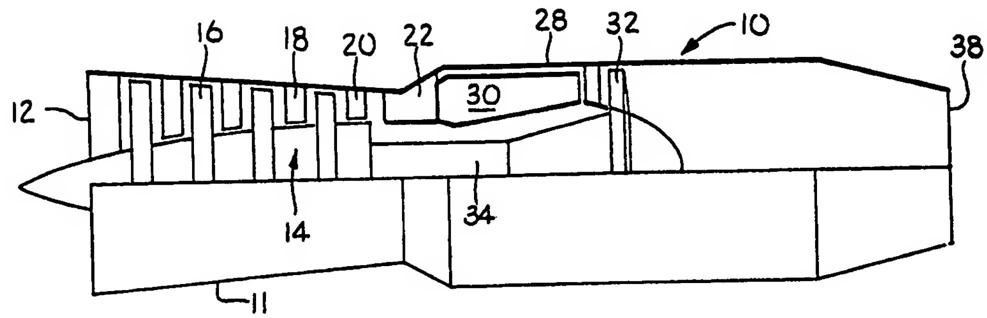

Fig 1

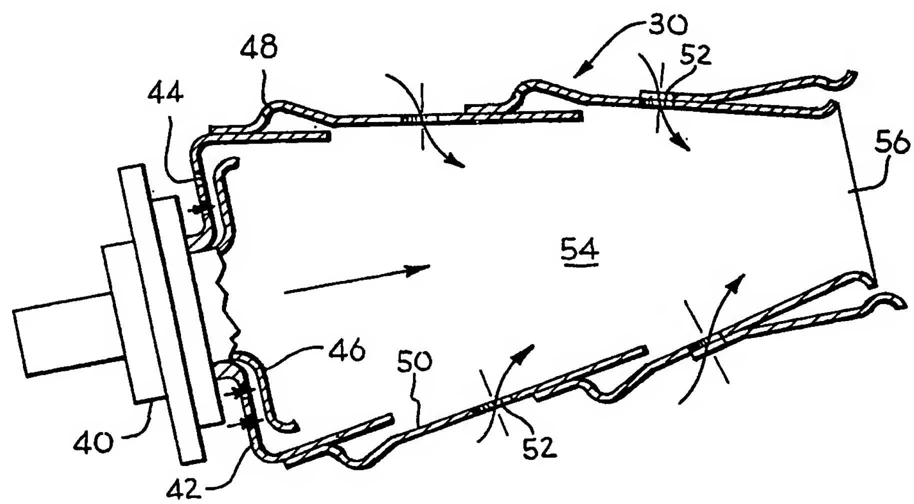

Fig 2 PRIOR ART

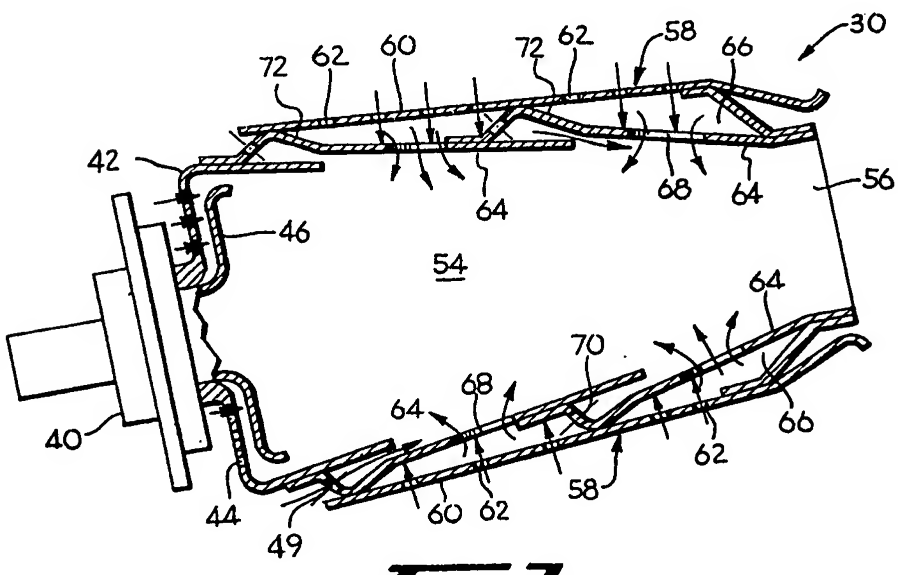

Fig 3

SPECIFICATION

Combustor liner with dual function cooling airflow

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to combustor liners for gas turbine engines and more particularly to those combustion liners that provide dilution airflow into the combustion zone.

2. Background of the Related Art

Increased efficiency in gas turbine engines is accomplished, in part, by an increase of the operating temperatures within the engine's combustor. In order to withstand these higher temperatures within an acceptable operating life term, it is necessary not only to use highly sophisticated alloys and materials, but to provide an efficient and reliable means for cooling liners of the combustion chambers.

One of the efficient techniques for cooling the combustor liner is that of film convection cooling. A protective film boundary of cool air is directed to flow along an inner surface of a combustor liner so as to insulate the liner from the adjacent hot gases of combustion. The cooling air film not only forms a protective barrier between the liner and the hot gases, but it also provides convective cooling of the liner itself. The air that is employed in this manner can be described as combustor liner film cooling air.

In addition to film cooling the combustor liner, compressed air discharged from the engine's compressor is also directed through the combustor liner to the interior of the combustor for the purpose of providing oxygen for the combustion processes occurring inside the combustor. Significant volumes of air must be directed into the combustor along the full length of the combustor structure in order to support the process of combustion. Air used in this manner is referred to as dilution flow air.

One fairly common way of introducing this dilution flow air has been the use of relatively large radius dilution flow apertures. These apertures are usually constructed in the form of tube members that extend through the entire length of the combustor liner.

One of the problems with current use of dilution flow apertures is that large amounts of compressed air are drawn into the combustor through a flowpath that does not fully utilize the cooling potential of the compressor discharge air. Substantial work has been expended to compress this air so it is very desirable to use this air in the most efficient way possible.

Therefore, it is an object of the present invention to provide a combustor liner structure that better utilizes the useful properties of dilution flow air.

It is another object of the present invention to utilize dilution flow air for additional purposes in the process of entering the zone of combustion.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, compressed air drawn from a region surrounding the combustor is utilized for at least two separate purposes. First, the air is drawn through an outer combustor liner for impingement cooling of combustor inner liner segments. Second, a portion of the air utilized for impingement cooling the inner liner thereafter flows through dilution holes for dilution flow into the combustor chamber. In addition, the remaining portion of the air originally used for impingement cooling can also be directed through film cooling holes for film cooling the inner walls of the combustor inner liner segments. The compressed air can be used in these separate ways because of a novel combustor liner construction wherein the inner and outer liner are separated by a space where the compressed air forms an impingement blanket between the two liners. The blanket of air serves as a source for dilution flow and can also be a source of film cooling air.

DESCRIPTION OF THE DRAWINGS

While the specification concludes with a series of claims that particularly point out and distinctly claim the subject matter comprising the present invention, a clear understanding of the invention is available from the following description, in conjunction with the accompanying drawings.

Fig. 1 is a schematic representation, partly in cross section and partly broken away of a gas turbine engine in which the present invention might be usilized.

Fig. 2 is a cross-sectional schematic illustration of a typical combustor from a gas turbine engine.

Fig. 3 is a cross-sectional schematic representation of one embodiment of the present invention as incorporated in a gas turbine engine combustor.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to Fig. 1, a typical gas turbine engine 10 is shown for the purpose of describing the functions of components within that engine. The engine 10 includes an outer housing 11 having an inlet end 12 for receiving ambient air into a multi-stage axial flow compressor 14. The compressor 14 includes rows of rotating compressor blades 16 interspersed between rows of non-rotating stator vanes 18. The rotating compressor blades 16 serve to compress the inlet air which, after undergoing compression, is discharged at a downstream end of the compressor 14 through a row of compressor outlet guide vanes 20, followed by an annular diffuser indicated generally at 22. The diffuser 22 discharges the pressurized compressor discharge air into a region surrounding a combustor 30, indicated generally at 28.

Portions of this compressed air in the region 28 surrounding a combustor 30 are directed into the combustor 30 where they are combined with fuel and ignited to form high-pressure, high-velocity combustion gases. The combustion gases are

directed at high velocity into a turbine section 32. The turbine section extracts work from the high-pressure combustion gases to drive the rotating blades of the compressor 14 by means of a connecting shaft 34. In addition, the turbine section 32 may extract additional work from the combustion gases for the purpose of driving a shaft providing mechanical power for whatever purpose the user of the engine desires. As an example, the mechanical power shaft might power a rotating helicopter blade (not shown) or a propeller (also not shown), or any of a variety of other uses. After passing through the turbine section 32 the combustion gases can be discharged into the atmosphere through an engine nozzle 38 thereby providing forward thrust to the engine 10.

The basic principles of gas turbine engines, their general structure, and operation are well known to those skilled in the art. The engine shown in Figure 1 is a turbojet variety, however, it should be understood that the present invention is applicable to any gas turbine engine. The engine 10 is described to promote the reader's understanding of the usefulness of the present invention in a gas turbine engine environment.

Referring now to Figure 2, a combustor 30 of a variety that might be employed in a typical gas turbine engine, such as the one shown in Figure 1, is shown for the purpose of describing airflow from the region 28 surrounding the combustor into the the combustor itself. The air in the region 28 surrounding the combustor 30 is highly compressed because it has been discharged from a compressor (not shown). It is also relatively cool in respect to temperatures inside the combustor where the combustion process occurs during engine operation.

The air discharged from the compressor 30, also known as compressor discharge air, is utilized for both supporting the combustion process and for cooling the combustor structure itself.

Fuel is injected into the combustor 30 through a fuel injector 40 as a fine stream of droplets that easily mixes with compressed air to form a combustible mixture. Compressor discharge air enters the combustor through a variety of orifices in the combustor structure. At its upstream end, the combustor 30 has a dome 42 provided with inlet air holes 44 that provide impingement cooling of a dome flange 46.

Moving in the downstream direction, film cooling holes 48 direct compressed air into the combustor in the form of a thick film that flows along inner walls 50 of the combustor structure. Further downstream, dilution air is introduced through dilution apertures 52. The purpose of this dilution air is to feed the combustion processes occurring within an inner chamber 54. The high-pressure, high-velocity combustion gases flow downstream through a combustor outlet 56 into a turbine section (not shown).

It can be readily appreciated by the reader that the compressor discharge air introduced into the combustor through the dilution aperatures 52 is used solely for the function of providing air to support the combustion processes.

Referring now to Figure 3, the present invention is shown as it might by employed in a typical combustor 30. As is most combustors, a fuel injection 40 is provided at an upstream end for injecting a fine spray of fuel into an inner chamber 54 of the combustor 30. Inside the chamber 54 the fine spray of fuel mixes with air and is ignited to form the high-pressure, high-temperature comustion gases that flow downstream out a combustor outlet 56. At its upstream end, the combustor takes the shape of a dome 42. The dome 42 is provided with inlet air holes 44 for impingement cooling of a dome flange 46. Moving downstream, a first row of film cooling air holes 48 are used to direct a film of cooling air along inner walls of the combustor for film cooling thereof. Up to this point, the description of combustor 30 shown in Figure 3 is similar to typical prior art combustors.

Downstream of a first row 49 of film cooling holes, the combustor has a liner structure 58 that is unique and utilizes dilution air in a new and useful manner. The liner 58 includes an outer liner wall 60 that is generally configured in a cylindrical shape around the engine's center line so as to define the basic confines of the combustor 30. A plurality of outer liner cooling air holes 62 are distributed in the outer liner wall 60 thereby providing access for compressor discharge air from the region 28 surrounding the combustor to flow through the outer liner wall 60. This compressed air flow through the outer liner cooling air holes 62 provides impingement cooling for one or more inner liner wall segments 64. The inner liner wall segments 64 are spaced radially in respect to the outer liner wall 60 thereby forming a space wherein an impingement blanket 66 forms of cooling air. The impingement blanket 66 serves to continuously cool the inner liner segments 64. The spacing is structurally formed by circumferential ridges 72 that are part of the inner wall segments 64. The ridges 72 abut the outer liner wall 60.

The air that forms the impingement blanket 66 thereafter can be utilized in two different ways. A portion of the impingement blanket air can be directed through dilution flow holes 68 to provide a substantial source of air to support combustion processes occurring inside the combustion chamber 54. The remaining portion of the air in the impingement blanket 66 can be directed through secondary film cooling holes 70 to form a film of cooling air along inside walls of the inner liner wall segments 64.

With this unique combustor liner structure, compressed air in the region 28 surrounding the combustor 30 can be utilized to perform either two or three separate and distinct functions. First, the compressed air is utilized for impingement cooling of the combustor inner liner wall segments 64. Secondly, this same air utilized for impingement cooling can be utilized for dilution flow into the combustor chamber 54 and/or

thirdly, for film cooling inner liner wall segments 64. Therefore, the air forming the impingement blanket accomplishes at least two functions and can potentially accomplish three functions.

An alternate arrangement is shown at a downstream section of the combustor 30 where impingement air is utilized for impingement cooling and dilution flow only. This alternate embodiment of the present invention is useful in segments of combustors where film cooling of inner walls is no longer as desirable.

One of the highly useful features of the present invention is that the potential cooling properties of dilution flow air are utilized for the purpose of impingement cooling of inner liner wall segments 64 of the combustor 30. This function is desirable in present-day combustors where combustion temperatures can exceed 3000 degrees Fahrenheit (1649 degrees Celsius) and can be very harmful to combustor materials.

In the embodiment of the present invention shown in Figure 3, a general flow distribution of cooling air can be described in the following manner. Of the total quantity (100 percent) of air flowing into the combustor inner chamber 54, approximately 30 percent of this quantity of air flows through the fuel injector 40 and the dome inlet holes 44 in the dome 42 and approximately another 10 percent of this air flows through the first row 49 of film cooling holes. The remaining 60 percent of this quantity of air is utilized for impingement cooling to form the impingement blanket 66.

From the impingement blanket 66, approximately 2/3 (or about 40 percent of the total quantity of inner chamber air) is utilized for dilution flow through the dilution holes 68 and the remaining 1/3 (or about 20 percent of the total quantity of inner chamber air) is utilized as film cooling air directed through the secondary film cooling holes 70.

It is to be understood that all of these percentages are only approximate and can be varied substantially while still performing the functions of the present invention.

As an example, in an embodiment of the present invention, a combustor liner might be utilized wherein none of the impingement blanket air is utilized for film cooling and all of it is directed through dilution air holes as dilution flow air.

While a preferred and an alternate embodiment of the present invention have been described for purposes of description, it shall be understood that modifications and variations will occur to those skilled in the art which do not depart from the scope of the invention a set forth in the appended claims.

CLAIMS

1. A combustor liner for a combustor in a gas turbine engine having a compressor providing compressed air, said combustor liner comprising:

an outer liner wall;

cooling air holes distributed in said outer liner wall, providing access for compressed air to flow through said outer liner wall;

one or more inner liner wall segments spaced apart from said outer liner wall to permit impingement cooling of said inner liner wall segments with said compressed air; and

dilution flow apertures distributed in said inner liner wall segments for providing dilution flow into said combustor, said dilution flow being provided at least partly by said air used for impingement cooling said inner liner wall segments.

2.The combustor liner recited in Claim 1 wherein all of said dilution flow is provided by said air used for impingement cooling said inner liner wall segments.

3. The combustor liner recited in Claim 1 wherein an impingement blanket of cooling air forms between said outer liner wall and said inner liner wall segments, and wherein said cooling air forming said impingement blanket provides impingement cooling of said inner liner wall segments and additionally provides a source of dilution flow air.

4. The combustor liner recited in Claim 3 wherein said inner liner wall segments have circumferential ridges formed therein and wherein said ridges abut said outer liner wall and thereby at least partially form spacing between said outer liner wall and said inner liner wall segments.

5. The combustor liner recited in Claim 3 wherein:

said combustor liner includes an impingement cooled dome at an upstream portion of said combustor wherein said dome is cooled with dome impingement air; and

a quantity of compressed air is directed into the combustor and this quantity is generally apportioned such that approximately 30 percent of the quality is used for dome fuel injection and dome impingement air, approximately 60 percent of the quantity is used to provide said impingement blanket for impingement cooling of said inner liner wall segments and approximately 10 percent of the quantity is used for film cooling only.

6. The combustor liner recited in Claim 5 wherein:

said air used for providing said impingement blanket is generally apportioned such that approximately one-third is used for film cooling said inner liner segments and approximately two-thirds is used for said dilution flow.

7. A combustor liner for a combustor in a gas turbine engine having a compressor, said liner comprising:

means for utilizing compressor disharge air for accomplishing a function of impingement cooling combustor inner liner wall segments and utilizing a portion of the same compressor discharge air

functioning as impingement cooling air to also function as dilution air to support combustion occurring within said combustor.

8. A combustor substantially as hereinbefore described with reference to and as illustrated in the drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1984. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.